BEHAVIORAL OBSERVATIONS ON AUSTRALIAN STILETTO FLIES (DIPTERA: THEREVIDAE) FROM SOUTHEASTERN NEW SOUTH WALES

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Abstract

Despite many years of study, there are few detailed reports on the behaviour of Australian stiletto flies. Over the past three years, a number of sites in southeastern New South Wales and the Australian Capital Territory were visited regularly to collect insects. Field observations on the Therevidae made at those sites are reported and discussed here.

Introduction

There are few detailed records of adult therevid behaviour in the field. White (1915) mentioned 'a silvery shimmering tomentum that covers all or part of the dorsal surface of the abdomen. This makes the male very conspicuous when in flight'. The website on Australasian Therevidae (Winterton *et al.* 2005) mentions a number of therevid behaviours, including hovering, swarming, attraction to water, nocturnal flight and attraction of some species to light traps. Over the 2003/04 and 2004/05 collecting seasons, therevids were collected and photographed, many of which can be found on the aforementioned website. The senior author regularly visited a number of sites and field observations of many different species of stiletto flies (Table 1) from those visits are provided here. Several of the species discussed are currently undescribed. Specimens collected from all the sites mentioned were identified, databased and housed in the Australian National Insect Collection at CSIRO Black Mountain, Canberra.

Observations

Bonython

Many detailed observations of therevid behaviour were made in a garden in Bonython (35°26'S, 149°04'E), a suburb of Canberra, Australian Capital Territory, where a large native garden was established in 1990. In 2000 a thick layer of river sand was placed over an old leaf litter surface of the property. In subsequent years, additional leaf litter has created a soil profile of sandy humus over clay. Six species of Therevidae, belonging to five genera, have been observed and 55 specimens collected from this garden over 4 years (Table 1).

Many male *Ectinorhynchus* sp. 1 (Fig. 1) were observed flying in sunny, warm weather from late September to mid-November. Two small areas, each about 2 m in diameter and only 10 m apart, frequently attracted swarms of males. The swarms were always low, 20-50 cm above ground. At times, as many as ten individuals occupied an area of about 1 m^2. Activity was greatest from mid-morning to early afternoon. Sometimes, individuals were as close

Table 1. Therevids collected at water or hand swept. Locations: B = Bonython, C = Corin Dam Road, G = Gilmore, J = Mt Jerrabomberra, K = Kambah, R = Broulee Island Nature Reserve, T = Tallaganda National Park.

Taxon	Nos.	At water			Netted		
		site	♂	♀	site	♂	♀
Acraspisa Kröber sp.	**9**	T	1	5	J B	2	1
Acraspisoides helviarta Hill & Winterton (Fig. 4)	**15**	T	2	10	T	2	1
Acupalpa albitarsa Mann	**9**	K		1	J	5	3
Acupalpa semirufa Winterton & Irwin (Fig. 3)	**2**				J	1	1
Agapophytus antheliogynaion Winterton & Irwin	**7**	T	5	2			
Agapophytus biluteus Winterton & Irwin (Fig. 2)	**4**	T	3	1			
Agapophytus palmulus Winterton & Irwin	**2**	T	2				
Agapophytus queenslandi Kröber	**11**	T	8	1	T		2
Anabarhynchus carduus Lyneborg	**6**				R	3	3
Anabarhynchus dimidiatus (Macquart)	**1**	T		1			
Anabarhynchus helvenacus White	**1**	T	1				
Anabarhynchus hyalipennis (Macquart)	**5**	C K	4	1			
Anabarhynchus maritimus Hardy	**3**				R	2	1
Anabarhynchus niveus Lyneborg	**7**	K		1	B G	1	5
Anabarhynchus paramonovi Lyneborg	**1**	C	1				
Anabarhynchus plumbeoides Lyneborg	**3**	K		1	B G		2
Belonalys obscura Kröber	**4**	T		4			
Bonjeania actuosa (White)	**26**	T	5	21			
Bonjeania clamosis Winterton & Skevington	**1**				B	1	
Bonjeania Irwin & Lyneborg sp. 1	**6**				G	4	2
Bonjeania Irwin & Lyneborg sp. 2	**1**	T		1			
Ectinorhynchus Macquart sp. 1 (Fig.1)	**19**				B	17	2
Ectinorhynchus sp. 2	**16**	K	2	3	B	11	
Ectinorhynchus phyciformis White	**20**	T	6	2	T	6	6
Ectinorhynchus pyrrhotelus (Walker)	**8**				R	6	2
Laxotela hauseri Winterton & Irwin	**10**	T	8	2			
Laxotela Winterton & Irwin sp. 1	**4**				T	2	2
Nanexila gracilis (Mann)	**2**				T	1	1
Neodialineura Mann sp. 1	**21**				B	20	1
Neodialineura Mann sp. 2	**10**	T		7	T	2	1
Neodialineura Mann sp. 3	**8**				G J	4	4
Parapsilocephala Kröber sp. 1	**1**				T		1
Parapsilocephala Kröber sp. 2	**1**				R	1	
Pipinnipons fascipennis (Kröber)	**7**	T	5		T		2
Pipinnipons Winterton sp. 1	**2**	T	2				
Taenogerella elizabethae Winterton & Irwin	**3**	K		2	J		1
Taenogerella platina Winterton & Irwin	**5**				J G	2	3
TOTAL	**261**		55	66		93	47

as 20 cm from one another. The hind legs hang beneath the body during flight, giving the fly a wasp-like appearance. When observed from a standing position, the silver abdomens of males (Fig. 1) are highly visible. As they change position there are flashes of silvery shimmer. From time to time they would all land, to rest on grass or herbage. This resting behaviour was interrupted if another male arrived, or one was disturbed, and all took flight. Occasionally, a male would chase another away from the swarm for several metres before returning.

Figs 1-4. Various Therevidae specimens, collected by D. Ferguson, photographed by C. Lambkin using techniques described by Fisher and Gaimari (2004). (1) Male *Ectinorhynchus* sp. 1 collected at Bonython, Sept. 2004, displaying silver tomentum on abdomen; (2) *Agapophytus biluteus* collected at mud at Tallaganda NP, Feb. 2004; (3) *Acupalpa semirufa* collected at Mt Jerrabomberra, Nov. 2004; (4) *Acraspisoides helviarta* collected at mud at Tallaganda NP, Dec. 2003.

Ectinorhynchus sp. 1 was only observed swarming at the garden in Bonython. While 19 specimens were collected, more than three times that number were observed. Females were rarely seen, presumably resting in the canopy of surrounding trees. Two females were observed in the cool of the morning on low foliage and collected (Table 1). An aerial mating was observed when a female flew from nearby tree foliage and tumbled with a male in the swarm, and then both flew, in copula, back toward the trees.

Ectinorhynchus phyciformis males were observed in the same garden in Bonython, in the mid to late afternoon, flying 4-6 m above ground in the space between trees. Individuals flew randomly in an area 40-50 cm in diameter, with hind legs hanging down. As the hind legs have a shining white basitarsus, *E. phyciformis* is easy to observe when behaving in this manner. *E. phyciformis* spends more time resting on foliage than actively flying. Occasionally, a male chased an *Ectinorhynchus* sp. 2 away before returning to the same leaf or rejoining the swarm.

Male *Ectinorhynchus* sp. 2 were observed flying in the Bonython garden from early to late afternoon during December 2004 and January 2005. This species flew 3-4 m above ground in the spaces between trees, at a lower level in the canopy than *E. phyciformis*. Individuals of *Ectinorhynchus* sp. 2 flew in a small space around 30-40 cm in diameter. Other males performed the same dancing behaviour a short distance away. Occasionally, if a male's dance space moved too close to another's, the second male chased the infringing male away for some distance before returning. Sometimes, a male would land on a leaf and rest. A large number of individuals were observed and 11 males collected (Table 1).

Males of *Neodialineura* sp. 1 were first observed in the Bonython garden in December 2004 and then repeatedly throughout January 2005. Individuals flew every day in swarms about 2 m above the ground, from early to late afternoon, on the western side of a *Eucalyptus* tree. Swarms ranged from only a few to as many as a dozen males. Generally the swarms were compact, occupying an area 50-60 cm in diameter, and were very active. These flies are small, less than 6 mm in length. If not for the silvery shimmer of the male abdomens, they would be very difficult to observe. Large numbers of *Neodialineura* sp. 1 were observed and 21 collected (Table 1).

Tallaganda National Park

Tallaganda National Park lies east of Hoskinstown, New South Wales, at an altitude of 1130 m (35°24'47"S, 149°32'22"E GPS). The environment is wet sclerophyll forest on decomposed granite substrata with a rich humus surface soil. Tall *Eucalyptus* trees tower above an intermediate storey dominated by *Acacia melanoxylon* R.Br. interspersed with *Banksia marginata* Cav. Ground cover is comprised of *Lomandra longifolia* Labill., *Dianella tasmanica* Hook.f. and *Pteridium esculentum* (G.Forst.) Cockayne. Areas of grassy

meadow, fringed by clumps of *Gahnia sieberiana* Kunth, surround patches of *Epacris microphylla* R.Br. The ground has a high load of very old, weathered, fallen timber, indicating that there have been no wild fires for many decades.

Many species of Therevidae have been observed and collected in this environment. During the summer months, between November 2003 and January 2005, 142 specimens from 19 species in 12 genera were collected (Table 1). In January 2004, after a prolonged hot, dry period, the damp mud at the bottom of a man-made reservoir was very attractive to a large number of therevids of many genera. Fifteen of the 19 species recorded in the area were collected at mud (Table 1). *Acraspisa* sp., *Acraspisoides helviarta* (Fig. 4) and *Pipinnipons fascipennis* would land some distance from the wet area and walk towards the moisture, but were always easily disturbed by sudden movements of the observer. In contrast, *Anabarhynchus* sp., *Belonalys obscura*, *Bonjeania actuosa*, *Ectinorhynchus phyciformis* and *Laxotela hauseri* would alight in the middle of the mud and, once settled and quietly drinking, were not disturbed by sudden movements. Activity around the moisture reached a peak around midday and throughout the early afternoon. No therevids were observed when the reservoir was completely dry. On a follow-up visit, two 20 litre containers of water were taken and emptied to recreate a damp base. Within minutes, high activity levels resumed. Four specimens of the rare *Agapophytus biluteus* (Fig. 2), described from only two specimens from Mittagong, NSW and Blundell's, ACT (Winterton and Irwin 2001), were collected over three occasions at the mud at the reservoir.

Pipinnipons fascipennis specimens were taken on a flowering *Baeckea utilis* F.Muell. ex Miq. and on *Persoonia* sp. growing near the reservoir in January 2004 and 2005. In the same area, two female *Agapophytus queenslandi* were collected after being observed sunning on old, weathered, fallen timber in December 2004 and January 2005. *Nanexila gracilis* was swept from *Lomandra longifolia* in the shade of tall *Acacia melanoxylon* trees in December 2004. On a hot and humid December afternoon in 2003, during the build-up to a large electrical storm, 10-12 adults of *Ectinorhynchus phyciformis* were observed sheltering on the base and lower branches of *Baeckea utilis*, a small shrub growing in a forest clearing. These might have been freshly emerged rather than sheltering from the pending storm.

Mt Jerrabomberra

At the summit of Mt Jerrabomberra (35°22'S, 149°13'E), near Queanbeyan, New South Wales, many *Acupalpa albitarsa* and three *Taenogerella platina* (including a mating pair) were swept from tree and shrub foliage in late 2003. Flowering *Cassinia quinquefaria* R.Br. attracted *Acupalpa albitarsa* in December 2002 and *T. elizabethae* and *Acraspisa* sp. in December 2004. Also in December 2004, a male *Acupalpa albitarsa* was swept from flowering *Kunzea ericoides* (A.Rich.) Joy Thomps. and two female *T. platina*

were collected sweeping over stony ground devoid of vegetation.. A female *Acupalpa semirufa* (Fig. 3) was swept from flowers of *Leptospermum multicaule* A. Cunn. in November 2004.

Broulee Island

Broulee Island (35°52'S, 150°11'E), on the south coast of New South Wales, is connected to the mainland by a 200 m sand spit. A small island rises steeply from a basalt rock shelf to form an almost flat, triangular plateau of rich sandy loam, approximately 700 m x 600 m in area, 27 m above sea level. Vegetation is a mix of *Casuarina glauca* Sieber ex Spreng., *Banksia integrifolia* L.f., *Rapanea* sp., *Elaeodendron australe* Vent., *Acacia mearnsii* De Wild. and *Acmena smithii* (Poir.) Merr. & L.M.Perry. The understorey is of *Acacia longifolia* subsp. *sophorae* (Labill.) Court, *Lomandra longifolia*, *Pteridium esculentum* and grasses. On an initial visit to the island four *Ectinorhynchus pyrrhotelus* were captured. On a second visit, further sampling was done over the whole island and a further four specimens were taken, including a mating pair. All the specimens were caught in an area of young *Rapanea* plants growing on the west of the island. A male *Parasilocephala* sp. 2 was collected on foliage of *Banksia integrifolia*. *Anabarhynchus maritimus* and the more numerous *An. carduus* were observed at rest on the sand spit and flew a short distance when disturbed.

Gilmore

A ridge east of Gilmore (35°25'S, 149°08'E), a suburb of Canberra, supports a dry sclerophyll forest. *Anabarhynchus niveus* and *Bonjeania* sp. 1 were collected amongst the understorey on the lower slopes. At the summit of 840 m, a male *Taenogerella platina* was swept from high in the foliage of an *Acacia melanoxylon*. Also at the summit, a mating pair of *Neodialineura* sp. 3 was noticed because of the flash of the male's silver tomentum. After they were disturbed into flight from their resting place on stony ground, the pair flew a short distance before landing back on the stones. Another two *Neodialineura* sp. 3 were swept from shrubs at the summit.

Kambah

Five *Ectinorhynchus* sp. 2 were found dead in a backyard swimming pool in the suburb of Kambah, ACT, in December 2003 and February 2004. From the same pool, two *Taenogerella elizabethae* and single specimens of *Acupalpa albitarsa*, *Anabarhynchus hyalipennis* ssp. *hyalipennis*, *An. niveus*, and *An. plumbeoides* were collected in February 2004 (Table 1).

Corin Dam Road

In March 2005, one *Anabarhynchus paramonovi* and four *An. hyalipennis* (Table 1) were collected at roadside puddles at 1220 m elevation on the Corin Dam Road (35°32'S, 148°53'E), 37 km SW of Canberra. Free-standing puddles were very attractive to adults, while the interconnected, slowly drained pools were not.

Discussion

Flies are often attracted to water, especially those whose immatures develop in aquatic environments, such as mosquitoes and midges. Because of this behaviour, pan traps, bowls or trays filled with water containing a small quantity of detergent or preservative (Southwood 1966) have been used to collect flies (Edwards and Huryn 1996, Kawaguchi and Nakano 2001). The attraction to water of flies with terrestrial immatures has been noted in the Bombyliidae (Lambkin *et al.* 2003) and Therevidae (Winterton *et al.* 2005).

Insects have often been recorded accumulating in numbers near water. This behaviour is common in butterflies, where it has been termed mud-puddling (Beck *et al.* 1999, Boggs and Jackson 1991, Shreeve 1987). However, in most butterfly species only males puddle (Beck *et al.* 1999, Molleman *et al.* 2004, Sculley and Boggs 1996). The nutrient most commonly considered to be the puddling stimulus for this behaviour in male butterflies is sodium (Beck *et al.* 1999, Molleman *et al.* 2004, Smedley and Eisner 1996), but there is also evidence for a role of nitrogen-rich compounds such as proteins (Beck *et al.* 1999), or those found in carnivorous animal dung (Boggs and Dau 2004). Studies on the effect of sodium in the diet of mud-puddling male Lepidoptera are contradictory. Molleman *et al.* (2004) were unable to find any significant effect on female reproductive output or any evidence that sodium acts as a nuptial gift in butterflies. However, earlier studies on moths (Smedley and Eisner 1996) found that sodium absorbed during mud-puddling was provided as a nuptial gift in the spermatophore and passed to the eggs. Alternatively, Hall and Willmott (2000) found evidence that suggested some riodinid butterflies mud-puddle to provide necessary nutrients to maintain high metabolic rates during rapid flight.

Attraction of adult flies to puddles of water has recently been reported in the Australian Therevidae (Winterton *et al.* 2005). Detailed observations from two locations are given in this study. The preferential attraction of free-standing puddles, compared with interconnected, slowly drained pools observed at Corin Dam Road, may be due to an accumulation of trace elements or salts. If therevids are also seeking sodium or nitrogenous compounds, those resources would be concentrated in smaller free-standing puddles, whereas flowing water would leach these substances, reducing their concentration in the connected pools.

In the Therevidae, attraction to puddles of water is not confined to males (Table 1). Male therevids do not transfer sperm in a spermatophore. However, in the Therevidae, females possess an unusual reproductive structure, a spermathecal sac (Winterton *et al.* 1999) that is only found in therevids and three related families of Diptera (Apsilocephalidae, Ocoidae and Scenopinidae). In the Australian Therevidae this structure is often voluminous, complex, multi-lobed, or made up of three entirely separate sacs. Winterton *et al.* (1999) suggested that the spermathecal sac might store a

nuptial gift from the male. As sperm have been found in the spermathecal sacs of some Australian Therevids (Winterton *et al.* 1999), it is more probable that the sacs act as an intermediate storage for sperm. Further investigation of this sac and its possible relationship with nutrient receipt and storage are needed.

Since both males and females are attracted to puddles (Table 1), it is possible that therevids are seeking extra nutrients to maintain high metabolic rates during rapid flight, as Hall and Willmott (2000) found in riodinid butterflies. Alternatively, as more females than males are observed at puddles (Table 1), females may be absorbing either sodium or nitrogenous compounds to aid in egg development.

Observing therevids in the field is generally difficult as they are alert, easily disturbed and move quickly and erratically. Thus sightings are generally brief. Swarming males are most easily observed. Male *Ectinorhynchus* and *Neodialineura* sp. 1 display in communal swarms, taking advantage of clearings with good light, at the expense of increased distance from females in the canopy. All female therevids, and males of *Bonjeania*, *Nanexila* and *Parapsilocephala*, are more drab, not having silvery tomentum covering the dorsal surface of the abdomen, and do not display; therefore they are more difficult to observe. Despite this, large numbers of these genera may be seen in specific locations.

Net-sweeping of foliage proved a productive way of sampling. Fourteen species were hand netted only and 12 species were collected only at mud or water. Eleven species were swept as well as being collected at mud or water. Netting from swarms collected large numbers of males. Sweeping generally produced more than twice as many males as females.

Many species, including *Acraspisa* spp., *Acupalpa albitarsa*, *Taenogerella platina*, *T. elizabethae* and *Neodialineura* sp. 3, have been collected on hill tops. Hilltopping behaviour has previously been observed in several groups of Australian flies, including bee flies (Bombyliidae) (Lambkin *et al.* 2003, Yeates and Dodson 1990) and big-headed flies (Pipunculidae) (Skevington 2001). *Patanothrix wilsoni* (Mann) males have been recorded hilltopping on large sand dunes in Wyperfeld National Park, Victoria (Winterton *et al.* 2001).

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